

Relativity Revisited

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Was Einstein wrong? This paper provides a detailed technical review of Einstein's special and general relativity from an astrophysical perspective, including the historical development of the theories, experimental tests, modern applications to black holes, cosmology and parallel universes, and last but not least, novel ways of expressing their seven most important equations.

I. INTRODUCTION

About a century after their inception, Einstein's theories of special [1] and general [2] relativity remain as topical as ever. The aim of this paper, developed for integration into the curriculum for MIT's relativity course 8.033, is to provide a detailed technical review of both the special and general theories from an astrophysical perspective. Particular emphasis is placed on the historical development of the theories, experimental tests and modern applications such as black holes, cosmology, eternal inflation and parallel universes. Novel ways of expressing the seven most important equations are presented, which is especially timely today [3, 4, 5, 6, 7].

To maximize the learning experience from this technical review, the reader is encouraged to sing it to the tune of *Yellow Submarine*, with italicized lines going like the chorus, ideally to guitar accompaniment by Enectali Figueroa.¹

II. SPECIAL RELATIVITY

Römer measured the speed of light,
and something basic just wasn't right.
because Michaelson and Morley
showed that aether fit data poorly.

We jump to 1905.
In Einstein's brain, ideas thrive:
"The laws of nature must be the same
in every inertial frame"
We all believe in relativity, relativity, relativity.
Yes we all believe in relativity, 8.033, relativity.

Einstein's postulates imply
that planes are shorter when they fly.
Their clocks are slowed by time dilation,
and look warped from aberration.
Cos theta-prime is cos theta minus beta ... over one minus beta cos theta.
Yes we all believe in relativity, 8.033, relativity.

With the Lorentz transformation,
we calculate the relation
between Chris's and Zoe's frame,
but all invariants, they are the same.
Like $B \cdot E$ and $B^2 - E^2$ minus p^2 .
... and the rest mass squared which is $E^2 - p^2$.
'cos we all believe in relativity, 8.033, relativity.

¹ An example of this is provided at <http://www.youtube.com/watch?v=5PkLLXh0NvQ>

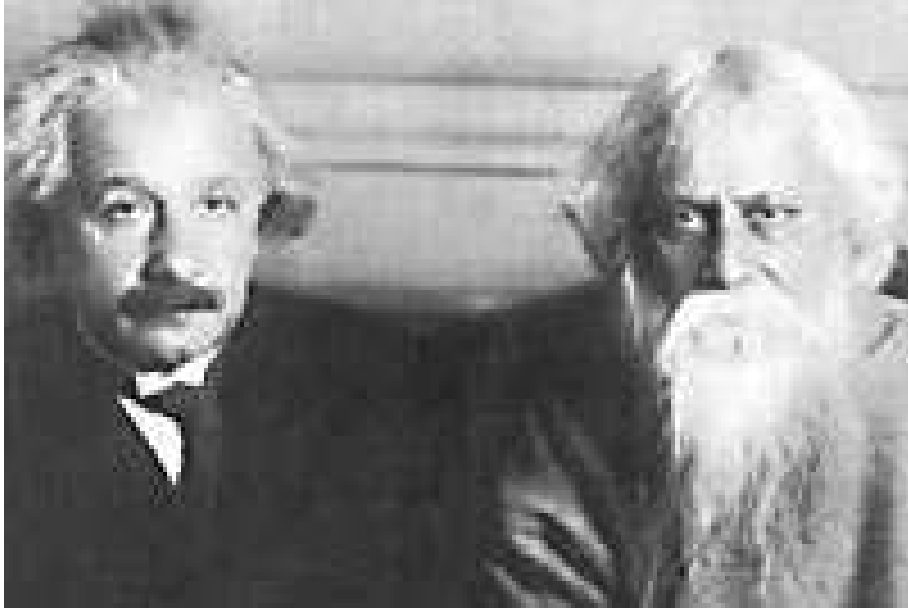


FIG. 1: Einstein contemplating his never published theory of Tagoreativity.
(This image was taken by American photographer Martin Vos in 1930 and published in 1930 without copyright notice.)

Soon physicists had a proclivity
for using relativity.
But nukes made us all scared
because $E = mc^2$.
Everything is relative, even simultaneity,
and soon Einstein's become a de facto physics deity.
'cos we all believe in relativity, 8.033, relativity.

III. GENERAL RELATIVITY

But Einstein had another dream,
and in nineteen sixteen
he made a deep unification
between gravity and acceleration.
He said physics ain't hard at all
as long as you are in free fall,
'cos our laws all stay the same
in a locally inertial frame.
And he called it general relativity, relativity, relativity.
And we all believe in relativity, 8.033, relativity.

If towards a black hole you fall
tides will make you slim tall,
but your friends won't see you enter
a singularity at the center,
because it will look to them
like you got stuck at radius $2M$.
But you get squished, despite this balking,
and then evaporate, says Stephen Hawking.
We all believe in relativity, relativity, relativity.
Yes we all believe in relativity, 8.033, relativity.

We're in an expanding space
 with galaxies all over the place,
 and we've learned from Edwin Hubble
 that twice the distance makes redshift double
 We can with confidence converse
 about the age of our universe.

Rival theories are now moot
 thanks to Penzias, Wilson, Mather & Smoot.

We all live in an expanding universe, expanding universe, expanding universe.
Yes we all live in an expanding universe, expanding universe, expanding universe.

But what's the physics of creation?
 There's a theory called inflation
 by Alan Guth and his friends,
 but the catch is that it never ends,
 making a fractal multiverse
 which makes some of their colleagues curse.
 Yes there's plenty left to figure out
 like what reality is all about about.
but at least we believe in relativity, relativity, relativity.
Yes we all believe in relativity, 8.033, relativity.

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